QUALITY REQUIREMENTS FOR PURCHASE ORDER

Prepared By
ATK Tactical Propulsion and Controls Division
Cage Code: 3BJAO

ES-111

REVOLUTION HISTORY

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The following ATK Tactical Propulsion and Controls Division Quality Assurance Provisions (QAP) apply to this purchase order.

GROUP 1 (REV 1, 1 APRIL 2003)

This purchase order line item is classified as a Group 1 procurement by ATK Elkton, LLC Quality Assurance.

QAP-E000, GENERAL QUALITY ASSURANCE PROVISIONS (REV3, 11 NOVEMBER 2004)

This document establishes general requirements for product assurance that are applicable to items ordered under the purchase order of which these provisions form a part. These provisions are intended to assure that the procured items meet the quality and reliability requirements of ATK Elkton and our customer, and apply unless expressly excluded or superseded in the purchase order. Additional Quality Assurance Provisions (QAPs) may also apply as designated in the purchase order.

1. CORRESPONDENCE

All correspondence relating to particular articles shall reference the specification(s) and/or drawings(s) (including number and revision) and the purchase order number. All correspondence shall be directed to the procurement division of ATK Elkton.

2. CONFLICT IN INSTRUCTIONS

In the event of apparent conflict among the purchase order provisions, the supplier shall obtain clarification from the procurement division of ATK Elkton as to the exact interpretation of requirements. Failure to obtain clarification may subject the procured articles to rejection.

3. RESPONSIBILITY FOR COMPLIANCE

The inspections set forth in the drawings and specifications shall become part of the supplier's overall inspection system or quality program. The absence of any inspection requirements in the drawings or specifications shall not relieve the supplier of the responsibility of assuring that all products or supplies submitted to ATK Elkton for acceptance comply with all requirements of the purchase order. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit ATK Elkton to acceptance of such defective material.

5. SPECIAL TOOLING AND SPECIAL GAGES AND EQUIPMENT

Special tools and special gages and equipment which are used for dimensional control and acceptance in lieu of inspection by standard methods or standard gages and equipment shall be designed and maintained to assure repetitive compliance to governing
drawings within the specified tolerance zone(s) of the dimension(s) being controlled or accepted.

6. FINAL ACCEPTANCE AT ATK ELKTON

Acceptance will be based on inspections performed at ATK Elkton facilities. ATK Elkton reserves the right to reject shipments that are found defective as a result of sampling.

9. RESUBMISSION OF REJECTED ARTICLES

All articles, including associated documentation, rejected by ATK Elkton and subsequently reworked to drawings, specifications, etc., shall bear indication of each resubmission. The accompanying documentation (discrepancy report, corrective action report, reinspection data, etc.), as required, shall be identified in the same manner as the article. The supplier shall contact the ATK Elkton procurement division for identification of articles submitted as replacement(s) for ATK Elkton rejected and supplier scrapped articles.

10. PACKAGING

When the drawing, specification, or purchase order lacks specific packaging instructions, the supplier shall use best commercial practices to ensure that the quality of the delivered part(s) is maintained and that damage, deterioration, and loss in transit are prevented.

Packaged items shall be free of dirt and other contaminants that would contribute to deterioration of the item or which would require cleaning by ATK Elkton prior to use. Items susceptible to corrosion or deterioration shall be provided protection such as preservative coatings, volatile corrosion inhibitors, or a desiccated environment. Items requiring protection from physical and mechanical damage, or which are fragile, will be protected by wrapping, cushioning, cartonizing, or other means to mitigate shock and vibration, and to prevent damage during handling and storage. Cushioning or wrap can be any suitable, appropriate material; except newspapers may not be used when painted surfaces are involved. Partitions or divisions must be used when necessary.

11. FOREIGN OBJECT DAMAGE PREVENTION

The supplier shall ensure that Foreign Object Debris (FOD) is controlled with the aim of preventing damage or degradation of the deliverable item, or of creating a hazardous condition to users of the deliverable item. Techniques that have been proven effective for control of FOD include: proper housekeeping; control of tools, personal items, and facilities; control of in-process hardware and consumables, including in-process scrap; kitting; and use of parts protective equipment.
**QAP-E001A, QUALITY ASSURANCE SYSTEM**  (REV 1, 1 APRIL 2003)

The supplier will, in the performance of this order, provide and maintain a quality assurance program that complies with or is equivalent to MIL-Q-9858, ANSI/ASQC Q9001:1994, or ANSI/ASQC Q9001:2000. ATK Elkton reserves the right to conduct a survey/audit of the supplier's facilities to determine the adequacy of the supplier's quality assurance system.

**QAP-E002A, SOURCE SURVEILLANCE**  (REV 0, 1 APRIL 2003)

ATK Elkton reserves the right to place quality assurance representatives (QARs) in the supplier's facilities, as deemed necessary, to ensure conformance with contractual requirements in any phase of design, processing, fabrication, testing, and inspection of the article(s) being produced. The supplier will provide all reasonable facilities and assistance for the safety and convenience of such personnel in the performance of their duties. Such representatives will be allowed full access to witness all operations involved in the fulfillment of this contract.

The supplier will grant the same access to representatives of the buyer’s customer, when accompanied by ATK Elkton personnel.

The supplier will secure the same privileges from lower-tier subcontractors.

**QAP-E002C, SOURCE INSPECTION**  (REV4, 29 SEP 2006)

Products or services furnished under this purchase order will be inspected for compliance with quality and technical requirements of the purchase order at the supplier’s facility prior to shipment. Notwithstanding the results of source inspection, final acceptance will occur at destination. The buyer’s procurement representative must be notified 5 working days in advance of the shipment. If an ATK Elkton QAR is in residence at the facility, notification through procurement is not required.

**QAP-E002D, MANDATORY INSPECTION VERIFICATION**  (REV 2, 3 NOVEMBER 2004)

Inspection of designated dimensional characteristics or processes is mandatory and must be witnessed and/or verified by the ATK Elkton QAR servicing the supplier's facility.

If an ATK QAR is resident at the facility, QAR will be given at least 24 hours' notice (one business day) prior to the inspection. If an ATK QAR is not resident, the supplier shall notify the buyer at least five business days prior to the inspection.
Mandatory inspection stations may be waived at the discretion of the QAR or quality assurance engineer. When inspection or verification is waived, the supplier will record "waived" on the inspection documentation adjacent to the waived station and note the date of the waiver and the name of the ATK Elkton representative granting the waiver.

A listing of mandatory inspection stations will be assigned after review of the build paper.

**QAP-E003B, GOVERNMENT SOURCE INSPECTION REQUIRED (REV 0, 22JAN2002)**

Government inspection is required prior to shipment from your plant. Upon receipt of this order, promptly notify the Government representative who normally services your plant so that appropriate planning for Government inspection can be accomplished.

**QAP-E004A, SUBCONTRACTED WORK (REV 3, 26 SEP 2006)**

The supplier is responsible for compliance with all quality and technical requirements imposed by ATK Elkton even when the supplier subcontracts part of the work. The supplier’s responsibilities with respect to subcontracted work include:

- Selection and control of subtier suppliers, unless otherwise specified in the purchase document.
- Transmission (flow down) of applicable quality and technical requirements to subtier suppliers
- Assuring traceability of items processed through subtier suppliers
- It is the supplier's responsibility to assure that the purchase order to the subtier supplier requires sufficient acceptance data to clearly fulfill the requirements imposed by the ATK Elkton purchase order to the supplier.

**QAP-E005B, INSPECTION PLANNING (REV 1, 1 APRIL 2003)**

The supplier will submit, for ATK Elkton approval, plans for performing tests on raw, semifinished, and/or finished materials, including proof pressure test. The data obtained from these approved tests will be made available to buyer and Government representatives upon request.

(NOTE: Approval of inspection planning applies to acceptance and qualification test procedures only at this time)
Any changes subsequent to the start of fabrication must be submitted for approval. Changes that affect the stated requirements of the part (Class I changes) shall be approved by the buyer prior to implementation. All other changes (Class II changes) may be submitted concurrently with implementation. Buyer approval of plans referenced above will not be required if the plans have been approved on a previous contract. A list of the previously approved documents that will be used, including the document title, name, revision, and approval reference, must be submitted to the QAR, if in residence, and to the buyer prior to use.

**QAP-E005C, APPROVAL OF PLANNING**

Prior to fabrication of any deliverable item, the supplier will provide, for buyer approval, the planned manufacturing, testing, and inspection procedures to be used in the fulfillment of this purchase order/subcontract. These procedures will include, as applicable, drawings of special tooling that may be used for dimensional acceptance and plans for performing tests on raw, semifinished, and/or finished materials, including special process techniques to be approved by a Level III at ATK. These procedures must document all operations that will be performed in conjunction with the fulfillment of this contract.

Buyer approval of plans referenced above will not be required if the plans have been approved on a previous contract. A list of the previously approved documents that will be used, including the document title, name, revision, and approval reference, must be submitted to the QAR, if in residence, and to the buyer prior to use.

Any changes to the approved planning must be submitted to the buyer. Changes that affect the stated requirements of the part (Class I changes) shall be approved by the buyer prior to implementation. All other changes (Class II changes) shall be submitted for concurrence in classification, and may be implemented immediately at the supplier's risk.

The supplier is responsible for meeting all drawing/specification and approved fabrication process requirements. Seller shall immediately notify the buyer of any change to seller's facility location(s) for the production of the material herein.

**QAP-E007, FIRST ARTICLE INSPECTION (FAI)**

First Article Inspection is required on this purchase order. One-hundred-percent inspection of all dimensions, including tool-controlled dimensions, drawing notes, material callouts, and specification requirements, will be performed on the first part produced.

Notify the buyer 5 working days in advance of anticipated FAI. ATK Elkton will either send a quality assurance representative to participate, or waive participation.
In the event FAI is waived, the supplier shall forward results to the buyer for concurrence. Shipment may not be made until either 1) concurrence is received, or 2) five working days have passed since receipt of FAI data at buyer’s facility.

If any of the below listed changes occur after FAI, notify the buyer so that ATK Elkton may determine if another FAI is required.

- A significant design or process change has been made that affects the original first article. An incremental first article will be performed, which will be applicable only to those characteristics affected by the change.
- A change in facilities or materials utilized to produce the article has taken place.
- New, reworked or revised special tools, gages or equipment, are introduced, when dimensional control of manufactured articles is affected.
- The supplier has not produced the item for a period of 12 months or longer.

**QAP-E007A, INSPECTION (REV 1, 8 MAR 2005)**

Nondestructive inspection, and inspection of critical and major characteristics as defined on the drawing, will be performed on each piece. Minor characteristics may be inspected 100% or may be sample inspected in accordance with ANSI Z1.4, Single sampling, General Inspection Level II, Normal Inspection. The AQL shall be chosen such that AC=0, RE=1. An attribute that is sample inspected and found discrepant shall be 100% screened.

The supplier is to perform dimensional inspection and record the results. Actual dimensions are to be recorded and reported for each piece inspected.

The supplier is responsible for meeting all dimensional requirements of the drawing.

**QAP-E008, CONTAMINATION CONTROL (TITANIUM) REV 0, 16 AUG 2002**

Control measures shall be taken to preclude any type of titanium corrosion. Specific actions to be taken include but are not limited to:

- Avoiding contamination by sulfur- or chloride-containing solvents, cadmium-plated components, and mercury.
- Immediate degreasing when fabrication is complete, or when additional work will not be performed for eight (8) or more hours.

**QAP-E008A FOREIGN OBJECT ELIMINATION PROGRAM (REV 0, 3 NOVEMBER 2004)**

The subcontractor shall establish procedures to implement a Foreign Object Elimination (FOE) program. Existing subcontractor practices and procedures that meet specific requirements shall
be documented and submitted to the buyer for review and concurrence (NOTE: this may also be reviewed at the suppliers facility). The procedures shall include the following elements as a minimum:

- Guidance on practices that, when followed, will eliminate damage caused by foreign objects during manufacturing, rework, and assembly and test, including but not limited to:
  - Inspection of materials and components on receipt at the work station for cleanliness and damage, and ensuring that they are clearly and properly identified;
  - Continual cleaning of finished and in-process materials and the surrounding work area as part of the normal in-process work effort;
  - Steps in shop documentation to check for the presence of FO;
  - Wearing attire that is appropriate for the specific work area – by both operators and transients – including removal of all personal items, including jewelry (e.g., rings, watches, necklaces, earrings, badges), and restraining of all eyewear and ear protection; (NOTE: this only applies as applicable to the type of work being preformed and the facilities internal requirements)
  - Elimination or limiting FO-causing processes;
  - A program to prevent tools, accompanying documents, and other items necessary to the manufacture of the item from becoming foreign objects; and
  - Ensuring that items not necessary to the manufacture of the item are not introduced into the work area

- Establishment and maintenance of a training program for the FOE program.

- Identification of those categories of employees who require FOE training.

QAP-E010A, IDENTIFICATION  
(REV 0, 22 FEB 2002)

The supplier is responsible for assigning lot or serial numbers as specified on the drawing. Lot or serial numbers shall not be duplicated on this purchase order, and shall not duplicate lot or serial numbers delivered against prior purchase orders.

If the drawing does not require serialization, the items shall be lot numbered. Serial numbers, when used, shall run consecutively. If material is rejected, the serial number of the rejected part will not be used again.
QAP-E011, MANUFACTURING RECORDS (REV 1, 20 FEB 2002)

The supplier will maintain records necessary to show conformance with all requirements of the purchase order/subcontract. These records include dimensional inspection records, process control charts, temperature recorder charts, x-ray film, nondestructive testing records, personnel certification documentation, nonconformance reports, process qualification data, hydrostatic test records, and certifications of materials and special processes. These records will be maintained for the greatest of:

- A period as required by the contract;
- Five (5) years; or
- The shelf/use life specified by the drawing or procurement specification.

QAP-E012A, CERTIFICATION OF CONFORMANCE (REV 1, 24 JULY 2007)

A Certification of Conformance is required with shipment. The certification must include, for each part covered by the certification, the following minimum information:

- Purchase order number
- Part number and revision of the item supplied, as specified on the purchase order
- Drawing or specification number, with revision, for subtier documents
- Serial numbers covered by the certification (if serialized)
- A statement that the certified part meets all drawing, specification, and purchase order requirements
- Signature of the quality assurance manager or other responsible member of the supplier's company
- The title of the person signing.

Material received without certification is subject to rejection and return to the supplier at the supplier's expense.

QAP-E012B, CONFIGURATION STATEMENT (REV 0, 06 JUN 2002)

All applicable drawing and/or specification numbers and their respective revision levels shall be included in the certificate of conformance.
QAP-E013A, CERTIFICATION REVIEW AT SOURCE  (REV 1, 1 APRIL 2003)

Certifications will be submitted to the ATK Elkton quality representative for review and approval 48 hours prior to shipment. This review and approval will not in any way reduce the supplier’s responsibility for complete conformance to contractual requirements.

QAP-E014, SPECIAL PROCESS CERTIFICATION  (REV 1, 26 APR 2006)

A Certification of Conformance to the special process(es) specified on the purchase order or drawing or specification is required with shipment. Material received without certification(s) is subject to rejection and return to the supplier at the supplier’s expense.

The certification will contain, as a minimum, the following:

- Purchase order number, part number, revision, and serial number(s) of the part(s) covered by the certification;
- Applicable specification including, as applicable: revision, notice, amendment, type, grade, class, method, or other qualifier, as specified on the purchase order, drawing or specification;
- Signature of the quality assurance manager or other responsible member of the supplier’s company
- The title of the person signing.

Test data, radiographs, and/or residual test specimens prepared in compliance with the specification or purchase order will be supplied with the delivered parts.

QAP-E016A, QUALITY PROVISIONS IN PROCUREMENT SPEC  (REV 0, 31 MAY 2002)

The supplier shall comply with all technical, quality assurance, certification, and packaging requirements of the specification to which this item is procured.

QAP-E018D, ATK-SUPPLIED MATERIAL  (REV 1, 29 NOV 2006)

The supplier will certify that ATK-supplied material was used in the fabrication of part(s), listing ATK shipping document number, part number, lot number(s), and/or serial number(s) as applicable. ATK-furnished material will be handled and controlled so as to ensure its proper use in conformance to all requirements. The supplier will not in any way be relieved of the responsibility for compliance to traceability, identification, and certification requirements.
ATK Supplied Material Certification

Supplier is required to **complete and return** this certification to ATK, with the purchased product, to provide traceability of ATK supplied material to the purchased product. Failure to return this certification may result in rejection of the purchased product at ATK inspection.

**ATK Supplied Material Data**

ATK Shipping Document Number _____________________________

ATK Material Part Number _____________________________

Material Specifications (if applicable) _____________________________

**Purchased Product Data**

ATK Purchase Order Number _____________________________

ATK Part Number from Purchase Order _____________________________

Supplier Lot Number (if applicable) _____________________________

Supplier Serial Number (if applicable) _____________________________
Manned Space:
Articles ordered in this contract are for use in Manned Space Flight. Materials, manufacturing, and workmanship of the highest quality standards are essential to astronaut safety. If you are able to supply the desired items with a quality which is higher than that of the items specified or proposed, you are requested to bring this fact to the immediate attention of the purchaser. This clause will be inserted in all subcontracts and purchase orders for such items down to the lowest tier.

Right of Access:
All work on the Orion Program is subject to inspection and test by Orbital, Lockheed Martin and the Government.

Over the life of the program, the Subcontractor shall recognize the right of Orbital, its customers and/or the appointed Government representatives to participate in or perform audits, reviews, Mandatory Inspection Points (MIPs), source inspections and witness tests at the Subcontractor or their supplier’s facilities as appropriate. The Subcontractor shall provide a minimum of five working days advance notice prior to upcoming MIPs. The Subcontractor shall arrange facilities and accommodations with access to necessary work tools (desk, telephone, and internet access) for any Orbital visitors and/or residents. Orbital may wish to have on-site residents where the Subcontractor’s work is performed. The responsibilities of Orbital’s S&MA representatives will be clearly defined by Orbital.

QAP-EV rev 0 (May 1, 2007) SELLER'S ACCEPTANCE TEST PLAN APPROVAL

The Seller shall obtain the Buyer's approval of detailed plans and procedures for accomplishing all acceptance test required by the Buyer's drawings and specifications. Approval must be obtained prior to the Seller presenting hardware for acceptance. The witnessing of a demonstration of the procedures and equipment by the Seller is at the option of the Buyer. The detailed plans and procedures will contain as a minimum:

A. A list of all instrumentation, non-standard instrumentation calibration procedures, points of measurement and accuracy of measuring system.

B. Test conditions.

C. Test sequence.

D. Test Methods including a detailed step-by-step procedure of each test using instruments listed according to Item A. above. Supporting data for critical parameters or special equipment, such as: error analysis, schematic diagrams and panel layouts, which are not necessarily part of the procedure, but are required to adequately evaluate the procedure, shall be submitted as supplemental information.
E. Sample data sheets.

F. Quantity of test samples.
   1. 100% testing
   2. Lot acceptance
      A. Definition of lot
      B. Determination of lot sample size

Buyer's approval must be obtained prior to Seller's implementation of subsequent changes to the acceptance test plan. Buyer approval of the test plan does not relieve the Seller of the obligation of meeting all requirements as listed in the Buyer's drawings and specifications.
NOTE: this requirement also applies to any qualification testing to be performed.
The following section is being flowed down as part of Orbital’s Subcontractor Product Assurance Requirements (SPAR) document 6029-GR2100, Revision -. Noted paragraph numbers are those corresponding to Orbital’s document.

2.0 APPLICABLE DOCUMENTS
The following documents provide guidelines from which the Orion Launch Abort System (LAS) program requirements are established. These documents form a part of this plan to the extent specified herein. Unless otherwise indicated, the latest revision in effect shall apply. In the event that specifications are obsolete or not maintained, the last active revision shall be used. In the event of conflict between requirements specified herein and other contractual documents, the following order of precedence shall apply: the applicable Subcontract, SOW, Performance Specification, and this Subcontract Product Assurance Requirements document.

2.3 GOVERNMENT / INDUSTRY DOCUMENTS
ANSI/ASQC Z1.4 Sampling Procedure and Tables for Inspection by Attributes
ANSI-ESD S20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ANSI/NCSL Z450-1 Calibration Laboratories, Measuring and Test Equipment- General Requirements
ASTM-A967 Passivation Treatments for Corrosion Resistant Steel
ASTM-E595 Standard Test Method for Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
ASTM-E1742 Standard Practice for Radiographic Examination
ASTM E8 Standard Test Methods for Tension Testing
ASTM-E1417 Inspection, Liquid Penetrant
AWS-C-3.3 Design, Manufacture and Inspection of Critical Brazed Components
CXP-02012 Methodology for Conduct of Project Constellation Hazard Analyses
CXP-02019 Constellation Program Requirements for Preparation of Hardware FMEA/CIL
FED-STD-H28/20 Screw-Thread Standards for Federal Services Revision A or Later
Inspection Section 20 Methods for Acceptability of UN, UNR, UNJ, M and MJ Screw
IPC/EIA/J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies
(Performance Class 3 with Space Addendum)
IPC-610 Acceptability of Electronic Assemblies
IPC-6610 Acceptability of Printed Circuit Boards
IPC-2221 Generic Standard on Printed Board Design, Amendment 1
IPC-6011(Class 3) Generic Performance Specification for Printed Boards
IPC-6012 Qualification and Performance of Rigid Printed Wiring Boards
IPC-6013 Qualification and Performance Specification for Flexible Printed Boards, Amendment 1
ISO-10012 Measurement Management Systems Requirements for Measurement Processes and Measuring Equipment
JPR 8080.5, E7 JSC Design and Procedural Standards, Section E-7, Electrical Components-restrictions on Use
JPR 8080.5, E22 JSC Design and Procedural Standards, Section E22, Ionizing Radiation Effects
JSC-49774A Standard Manned Spacecraft Requirements for Materials and Processes
MIL-C-5541 Chemical Conversion Coating
MIL-HDBK-61A Configuration Management Guidance
MIL-HDBK-103 List of Standard Microcircuit Drawings
MIL-HDBK-217 Reliability Predictions of Electronic Equipment
MIL-M-35810 Microcircuits, General Specification for
MIL-P-116 Preservation, Methods of
MIL-PRF-31032 Printed Circuit Board/Printed Wiring Board, General Specification
MIL-PRF-35835 Integrated Circuits (Microcircuits) Manufacturing, General Specification for
MIL-PRF-38534 Hybrid Microcircuits, General Specification
MIL-PRF-39003/10B Capacitors, Fixed Electrolytic (Solid Electrolyte), Tantalum (Polarized, Sintered Slug), Established reliability, Styles CSS13 and CSS33, (High Reliability Applications)
MIL-PRF-49470 Capacitor, Fixed, Ceramic Dielectric, Switch Mode Power Supply (General Purpose and Temperature Stable), Standard Reliability and High Reliability General Specification For,
MIL-STD-129 Marking for Shipment and Storage
MIL-STD-883 Test method of Standard Microcircuits
MIL-STD-889 Dissimilar Metals
MS20003 Indicator, Humidity, Card, Three Spot, Impregnated Areas
MSFC-STD-557 (1980) Threaded Fasteners, 6 Al-4V Titanium Alloy, Usage Criteria for Spacecraft Applications
NAS-412 Foreign Object Damage/Foreign Object Debris (FOD) Prevention
NASA-EEE-INST-002 Instructions for EEE Parts Selection, screening, Qualification and Derating
NASA-HDBK-7005 Dynamic Environment Criteria
NASA-STD-5006 General Fusion Welding Requirements for Aerospace Materials Used in Flight Hardware
NASA-STD-6001 Flammability, Odor, Offgassing and Compatibility Requirements and test Procedures for Materials in Environments that Support Combustion
NASA-STD-8739.1 Workmanship standard for Staking and Conformal Coating of Printed Wiring Boards and Electrical Assemblies
NASA-STD-8739.3 Soldered Electrical Connections
NASA-STD-8739.7 Electrostatic Discharge (ESD)
NASA-STD-8739.8 NASA Software Assurance Standard (Chapters 6 and 7)
NHB-8060.1 Office of Safety and Mission Quality Flammability, Odor, Offgassing, and Compatibility Requirements
NPR 8580.1 Implementing the National Environmental Policy Act and Executive Order 12114
QML-19500 Semiconductor Services, General Specification
SAE AS9100B Quality Management System- Aerospace-Requirements
SAE AS9003 Inspection and Test Quality System

2.4 GOVERNMENT / INDUSTRY REFERENCE DOCUMENTS
SAE-AMS-2759C Heat Treatment of Steel Parts, General Requirements
3.1.2 Product Assurance Reporting
Safety & Mission Assurance reporting shall be submitted as part of other subcontractor reporting requirements as specified in the SOW. The topics to be covered are non-conformances for the most recent period, significant changes or activities that affect assurance of flight hardware or software, progress on analyses that verify assurance activities, progress with environmental testing or any other concern that may impact product assurance. The format of this reporting activity shall be in subcontractor standard format, with ATK approval.

3.1.3 Right of Access
All work on the Orion Program is subject to inspection and test by ATK, Orbital, Lockheed Martin and the Government. Over the life of the program, the Subcontractor shall recognize the right of ATK, its customers and/or the appointed Government representatives to participate in or perform audits, reviews, Mandatory Inspection Points (MIPs), source inspections and witness tests at the Subcontractor or their supplier’s facilities as appropriate. The Subcontractor shall provide a minimum of five working days advance notice prior to upcoming MIPs. The Subcontractor shall arrange facilities and accommodations with access to necessary work tools (desk, telephone, and internet access) for any ATK visitors and/or residents. ATK may wish to have on-site residents where the Subcontractor’s work is performed. The responsibilities of ATK’s S & MA representative will be clearly defined by ATK.

3.3.3 Parts Application Derating Stress Analysis
EEE-INST-002 or ATK-approved equivalent derating requirements shall be applied to the application of all electrical, electronic and electromechanical (EEE) parts. Derating shall be performed in accordance with the following conditions:

a. Worst case power dissipation, voltage, and/or current for each piece-part circuit operation during any phase of integration/test or on-orbit operation.

b. Worst case operating temperature (including test environments) corresponding to the conditions of item a above. The thermal model noted in paragraph 3.3.3 shall be used as an input to the part derating analysis.

c. Derating shall be applied as required for mitigation of radiation or other environmental, design, or operational effects, e.g., part parameter variations due to total ionizing dose and derating for power MOSFETS due to heavy ion effects.

All parts (excluding GSE) shall meet derating requirements or shall require explicit ATK review and approval. Parts failing the derating criteria shall be evaluated in their typical application stress environment. If the part exceeds derating in this typical environment, an examination of the frequency of performance in the high application stress environment shall be made. Each derating noncompliance shall be evaluated on a case-by-case basis by ATK. The Subcontractor shall submit a Preliminary derating analysis to ATK for review and approval prior to PDR. The final derating analysis shall be submitted to ATK prior to CDR. Any changes to parts application stress shall cause the analysis to be updated and resubmitted to ATK.

3.3.4 Failure Modes and Effects Analysis
A Failure Modes and Effects Analysis (FMEA) shall be performed per the SOW to verify the failure tolerance requirements of the Performance Specification are met, to identify and eliminate Single Point Failures (SPFs), to assess critical failure areas, and to minimize operational risk caused by catastrophic or marginal failure of critical parts. For electrical assemblies, the FMEA shall address effects caused by common failure modes (i.e., short circuit, open circuit, parameter drift). CxP-02019 shall be used as a guide in preparing the FMEA. The
FMEA results shall be used to determine the need for fault-tolerant design features, additional derating, higher reliability parts, ground operations contingency planning for on-orbit anomalies, and appropriate quality inspection points. The Subcontractor shall require ATK's approval for any SPF that cannot be eliminated from the design. FMEA does not apply to GSE. Initial FMEAs shall be performed at the component functional level to identify loss of function and alternatives that may be used to restore, partially or completely, that function. Where it is determined that a critical failure exists, the analysis shall be extended through progressively lower levels from functional block down to the piece part level as needed. FMEAs shall be performed on:

a. Interfaces of each functional block,
b. Failure modes associated with common power lines,
c. Isolation circuits for redundant elements,
d. Cross-strapping circuitry,
e. Flight hardware interfaces with GSE,
f. Non-explosive actuator and pyro-actuator circuitry (if applicable),
g. Single Event Effect (SEE) susceptible parts, and
h. Mechanisms (as applicable); a Fault Tree Analysis shall be performed on all mechanisms.

FMEA outputs shall also be used to ensure that adequate telemetry and command capabilities are available to detect and control failures, identify design incompatibilities and inadequacies and verify, as far as possible, that all redundant elements and all critical and major failure modes can be fully tested.

Severity categories defining the criticality of the failures are shown below.

- Category 1 Catastrophic – A failure that could result in loss of life or system loss.
- Category 2 Critical – A failure that could result in severe injury, major system damage that may result in mission loss.
- Category 3 Marginal – A failure that could result in minor injury, minor property damage, or minor system damage that may result in delay or loss of availability or mission degradation (e.g., loss of redundancy)
- Category 4 Minor – A failure not serious enough to cause injury, system damage, or loss of mission objectives.

The Subcontractor shall submit a preliminary and Final FMEA to ATK for review and approval in accordance with the SOW. Any design changes that impact the FMEA shall cause the analysis to be updated and resubmitted to ATK.

### 3.3.5 Critical Items List (CIL)

The Subcontractor shall prepare and maintain a Critical Items List per the SOW. CxP-02019 shall be used as a guide in preparing the CIL. The purpose of the list is to identify mission critical items and document the controls and measures implemented to minimize their risk.

Items entered on the list include:

a. Items causing a Single Point Failure,
b. Parts out of accepted de-rating conditions,
c. Items that may cause or control safety hazards,
d. Items or processes using devices without prior flight heritage technologies,
e. Age/wear sensitive components,
f. Moving mechanical assemblies,
g. Procurement schedule critical components/piece parts,
h. Parts/components utilized extensively throughout the system/subsystem,
i. Parts/components with high or questionable failure rate or ones with a worst-case lifetime shorter than the mission requirement,
j. Items requiring special handling or that are difficult to test on the ground, and
k. Materials used in critical applications that have outgassing rates exceeding program requirements.
The Critical Item List shall identify which of the above categories the item falls under. The List shall:
a. Determine and document the requirements to be imposed on each Critical Item,
b. Define the appropriate compensatory controls to mitigate the risk throughout all program phases, and
c. Mandate the effective implementation of the above requirements on the responsible organization.
The Subcontractor shall submit a preliminary Critical Items List to ATK for review and approval prior to PDR. The Subcontractor shall submit the final Critical Items List prior to CDR. The list shall be updated, as required, and resubmitted to ATK.

3.3.6 Service Life
All parts and materials shall be selected and qualified to support the required mission lifetime as defined in the Performance Specification or SOW. Specified environments and ground storage conditions are defined in the SOW or component’s Performance Specification. For parts and assemblies having life characteristics defined by operation cycles (e.g., electro-mechanical devices such as relays, switches, etc.), the life assessment shall consider the expected number of cycles during ground test followed by normal operation over the life of the mission. Any limitations on ground test cycles shall be defined by the Subcontractor and shall be included in the Contract End Item (CEI) Interface Control Document (ICD). As a minimum, components that have cycle lifetime limitations shall be qualified to at least two times their expected lifetime.

3.3.7 Worst Case Analysis
The Subcontractor shall perform a worst case analysis (WCA) on all electronic circuits per the SOW. This analysis shall verify the design functional margin based upon expected worst case combination of potential operating conditions, temperature design limits, individual piece-part tolerance, part aging, voltage and frequency tolerance, and radiation degradation (e.g., total dose and single event effects). Degradation factors applied in the analysis shall be justified. As a part of this effort, power supply circuits shall be analyzed for transient conditions - this condition shall be analyzed for impact to all connected circuitry. An Extreme Value Analysis (EVA) methodology shall be used initially for all circuits, with RSS and Monte Carlo techniques used for circuits that fail EVA. (Worst Case Analysis does not apply to GSE.)
The Subcontractor shall submit a preliminary WCA to ATK for review and approval prior to PDR. The Subcontractor shall submit the final WCA in accordance with the SOW. Any design changes that impact the WCA shall cause the analysis to be updated and resubmitted to ATK.

3.3.8 Mishap and Safety Statistics Report
The Subcontractor shall perform mishap investigations, generate mishap reports and provide monthly mishap and safety statistics report in accordance with the SOW. Mishap Reporting shall start with the manufacturing of hardware.
The objective of the mishap and close call investigation is to improve safety by identifying what happened, where it happened, when it happened, why it happened and what should be done to prevent reoccurrence and reduce the number and severity of mishaps.
The supplier shall report unplanned events that result in the following:
1. Injury to non-NASA personnel caused by NASA ops
2. Damage to public or private property caused by NASA ops or NASA funded development or research projects
3. Occupational injury or illness of NASA personnel
4. Damage or destruction of NASA property
Test failures involving damage to equipment or property as a result of testing are not considered mishaps if:
1. The test article is not flight hardware
2. The testing is part of an authorized research/development/qualification certification program
3. Damage is limited to the test article and test instrumentation
4. Risk of damage to the test article was accepted explicitly by Program/Project management
5. The test team performs a test failure analysis and generates a technical report instead of treating it as a mishap

3.4 EEE PARTS PROGRAM
The Subcontractor shall implement a parts program that defines the selection and controls the use of EEE parts in order to meet the requirements of the Orion program.

3.4.1 General EEE Parts Requirements
EEE parts include, but are not limited to, capacitors, circuit breakers, connectors, crystals, diodes, filters, fuses, inductors, microcircuits (monolithic and hybrid), oscillators, printed wiring boards, relays, resistors, surge arrestors, switches, thermistors, thermostats, transformers, transistors, varistors, wire and cable. Subcontractors are encouraged to utilize existing plans and procedures with ATK concurrence, consistent with the item's performance requirements. The subcontractor shall use the following applicable standards for EEE Parts:
• JPR 8080.5, E7 (JSC Design and Procedural Standards, Section E-7, Electrical Components-restrictions on Use.)

3.4.2 Standard Parts
Parts selected from the following lists shall be considered standard:

a. For new designs: parts that meet Level 1 requirements of NASA EEE-INST-002 or NASA Parts Selection List (NPSL)
b. Semiconductors listed in QPL-19500 as JANS. (JANTXV or JANTX are acceptable for the semiconductors for demonstration flights Pad Abort-1 and Ascent Abort-1, and GSE parts only.)
c. Hybrid Microcircuits per MIL-PRF-38534, Class K, and Monolithic Microcircuits per MILPRF-38535, Class V, and Monolithic Microcircuits per MIL-M-38510, Class S, or equivalent, (Class B are acceptable for the semiconductors for demonstration flights Pad Abort-1 and Ascent Abort-1, and GSE parts only.)
d. Established Reliability (ER) military passive devices with R failure rate level or better,
e. Microcircuits manufactured by a DSCC-certified supplier, having QPL or QML listing status for the technology being procured and produced on a certified line. The microcircuits shall be procured to an SMD drawing or to the supplier’s in-house high reliability processing flow,
f. Microcircuits procured to an SMD drawing not meeting the criteria of item f. above, from an authorized supplier in MIL-HDBK-103 and microcircuits procured as MIL-STD-883 class B or equivalent. PIND testing and Group A inspection shall be performed on procured lots. When QCI test data is not available, additional testing may be performed to verify the device suitability for flight hardware.
Parts with higher quality levels than outlined above are also considered standard. These criteria shall apply to the selection, screening, and qualification of all EEE parts utilized in the design.
3.4.3 Non-standard Parts
All parts that do not meet the criteria of the paragraph above are considered nonstandard and must be reviewed and approved on a case-by-case basis by ATK. The Subcontractor shall submit a request for use of each nonstandard part. The subcontractor shall supply sufficient supporting information as justification for use on the Orion program. This shall include a complete description of the candidate part, screening/qualification summary, and a description of application derating. As a guide, nonstandard parts shall be processed to the nearest equivalent space-qualified part to assure that program requirements shall be satisfied.
Plastic encapsulated microcircuits (PEMs) are nonstandard parts, by definition. Where PEMs are required to meet application requirements (and a standard hermetic part is not available), the manufacturer’s commercial qualification data shall be reviewed to assess suitability for use. An investigation of the manufacturer’s quality and reliability history shall be conducted prior to selecting PEMs for use in the design. Dependant on manufacturer selected, and previous part heritage, ATK may require certification, qualification, and screening to MIL-PRF-38535, device class N (for PEMs) or to NASA EEE-INST-002 (Level 1).

3.4.4 Special Parts Requirements

3.4.4.1 Additional Parts Testing/Analysis
Selected part categories require additional testing to meet mission requirements, as follows:
a. All hybrid devices shall be processed to level K of MIL-PRF-38534. Devices that incorporate hybrid technology shall be subjected to a 100% customer pre-cap inspection to ensure that adequate workmanship standards are employed. Destructive physical analysis (DPA) may be performed in lieu of customer pre-cap.
b. Devices or parts containing pure tin (purity higher than 95%) shall not be used without ATK approval. Devices containing pure tin must be identified to ATK and shall have adequate protection to prevent adverse effects on adjacent elements.
c. Any device that is custom, semi-custom, or which incorporates a significant portion of “touch labor” shall be extensively screened and lot-qualified by the manufacturer. This class of parts shall be subjected to Class-S/Grade-1 equivalent requirements.
d. Use of wire containing PTFE or FEP Teflon insulation is not permitted unless the application is reviewed and approved by ATK (cross-linked ETFE wire insulation is preferred).

3.4.4.2 Optional Up-screening
The subcontractor shall quote up-screening/testing beyond that specified in paragraph above. The following optional tests shall be individually quoted:
a. DPA and RGA (where applicable) on all lots of cavity devices, in accordance with MIL-STD-1580 or manufacturers equivalent procedure. A three piece sample shall be used.
b. Surge current testing on tantalum capacitors
c. Radiographic examination on all devices
d. Stacked capacitors shall be processed to MIL-PRF-49470. A three piece DPA shall be conducted on all lots of stacked capacitors.
e. Hybrid Crystal oscillators shall be up-screened per MIL-PRF-38534.
f. Relays shall be procured to an SCD that includes screening to the nearest military specification and that includes Millipore inspection and internal visual inspection.
g. Ceramic caps rated <100v that are used in applications under 10v shall be crosssectioned to verify that the dielectric thickness is >0.8mil should receive 85/85 testing.

h. Custom hybrid devices/MCMs shall be processed per Level K requirements of MILPRF-38534. The following specific requirements apply:
   1) a 10-piece element evaluation shall be conducted on each die type
   2) a pre-cap inspection shall be performed by the procuring agency
   3) substrates shall be qualified, including cross-section analysis, high temperature aging, adhesion testing, element evaluation, etc.
   4) Substrates shall be screened, including thermal cycling, radiographic inspection, acoustic microscopy, etc.

3.4.4.3 Parts Age Limitation
No EEE parts older than five (5) years as indicated by their lot date code shall be used. Plastic Encapsulated Microcircuits (PEMs) have an age limitation of three (3) years. If the supplier desires to use older EEE Parts, an approved waiver from ATK is required.

3.4.4.4 Derating Criteria
The Subcontractor shall apply de-rating criteria to all EEE parts applications as specified in section Parts Application Derating Stress Analysis.

3.4.5 Radiation Hardness Assurance (RHA)
The Subcontractor shall verify by analysis with supported test data that EEE parts utilized in spacecraft component hardware will withstand the required radiation environment for the mission duration as specified in the Performance Specification or SOW. These requirements shall be an integral part of the program throughout design, test, and production. Due to the short mission duration and the low altitudes achieved by the LAS, only Single Event Effects must be analyzed. A radiation analysis shall be generated to assure that all parts are acceptable for the mission, and meet required margins on all effects. Parts requiring lot hardness testing, radiation packaging, and/or localized shielding shall be identified.
The Subcontractor shall submit a radiation analysis to ATK for review and approval prior to CDR. Any design changes that impact the radiation analysis shall cause the analysis to be updated and resubmitted to ATK.

3.4.5.1.1 Radiation Lot Acceptance Tests (RLAT)
In the absence of similarity or lot data guaranteeing radiation survivability and part performance, RLAT shall be performed on six devices from each wafer lot or four devices from each wafer. Lot acceptance testing shall simulate the worst-case bias conditions used in the design and shall be conducted to at least twice the worst case predicted mission exposure. Any RLAT testing conducted under this subcontract shall be coordinated with ATK, to help identify any economies of combined testing with other suppliers, ATK, etc.

3.4.5.2 Single Event Effects (SEE)
All EEE parts shall be evaluated for susceptibility to single event effects (SEE), including but not limited to: single event upset (SEU), single event latch-up (SEL), single event burnout (SEB), single event gate rupture (SEGR) and single event transient (SET) caused by atmospheric neutrons and other energetic particles. The predicted radiation environments for the mission orbit are defined in the Performance Specification.
Parts utilized in component hardware for the spacecraft shall be verified by analysis and/or supported by test data to withstand the required radiation environment for the mission duration at the end of life (EOL) level reliability. Single-event effect sensitivity and analysis for the spacecraft components shall be documented, and worst case propagation of these effects shall
be analyzed to ensure reliability and safety of the LAS

3.4.5.2.1 Single Event Upset (SEU)/Single Event Functional Interrupt (SEFI)
EEE parts shall be selected to minimize the frequency of SEU and SEFI, and all parts that may be susceptible to SEU/SEFI shall be identified. Upsets shall be allowed only if it can be shown that no significant permanent or temporary degradation in operation of the spacecraft will occur. The Subcontractor shall document the effects of the upset rate for each part in the FMECA, with an emphasis on analyzing SEU propagation or SEFI impact. Circuit applications for parts so identified shall be investigated to ensure that adequate circuit protection is provided or that implemented designs contain features which overcome or eliminate potential single event upset occurrences; such as using triple mode redundancy (TMR), Error Detection and Correction (EDAC), watchdog schemes, memory wash, etc.

3.4.5.2.2 Single Event Latch-up (SEL)
EEE parts susceptible to destructive SEL in the mission environment shall not be used.

3.4.5.2.3 Single Event Burn-out/Gate Rupture (SEB/SEGR)
Proper de-rating of drain and gate voltages can mitigate SEB and SEGR risk in FETs. FETs used in flight hardware must have drain and gate voltages derated to less than 50% of the rated device drain and gate voltage applied under any circumstance or operating mode (including worst case applied transient, DC or AC voltage). This requirement shall be documented as part of the de-rating analysis.

3.4.5.2.4 Single Event Transients (SET)
All analog parts/circuits shall be selected to achieve immunity to SET to the greatest extent possible. All analog parts/circuits shall be evaluated for susceptibility to SET – all applicable test data shall be reviewed to assure low susceptibility to these effects. In the absence of specific part SET data, circuit analysis shall demonstrate that all circuits operate in accordance with specifications when subjected to an SET of 15 microseconds duration with rail to rail voltage amplitude on op-amps, references, regulators, comparators, optocouplers, pulse width modulators, digital-to-analog converters, phase locked loops, FET drivers, analog switches, and other linear/analog parts.

3.4.7 Failure Reporting and Analysis
The Subcontractor shall define and implement a failure reporting system that addresses both flight hardware and flight software including critical GSE that interfaces with the flight hardware. Failure reporting and analysis shall begin at the time of first application of power to a space flight circuit card assembly or first application of software into the flight hardware system, or first actuation of a flight mechanical element. The Subcontractor shall notify the Orion program within 24 hours of problem/failure/anomaly occurrence. Problem identification and failure analysis shall be initiated, documented, and continued until resolved to successively lower levels of assembly, ending with, if necessary, a Destructive Physical Analysis (DPA) at the piece-part level. The scope of the analysis shall be to identify the source (i.e., root cause) of the failure, any potential overstress conditions on other EEE parts in the circuit, and develop a positive corrective action to eliminate failure recurrence.

3.4.8 Traceability
The Subcontractor shall maintain traceability of installed flight parts by part number, manufacturer, lot number, and date code (including individual part serialization when provided via the certificate of compliance), and to the data supplied through the as-built configuration documentation (i.e., manufacturing records for each deliverable item).
The Subcontractor’s traceability system shall ensure the capability to correlate historical records from initial procurement and receipt of items through storage, kitting, fabrication, assembly, test, and final acceptance of deliverable qualification and flight hardware. The system shall permit the tracing of the quality histories of assemblies, components, parts, and materials to the procurement document and shall provide for (1) cross-referencing of traceability data to assembly documentation, and (2) the storage of accumulated history and traceability data. The Subcontractor shall use photographic records to supplement manufacturing records on part number and lot date code traceability.

3.4.9 Industry Alerts (GIDEP)
The Subcontractor shall participate in the Government/Industry Data Exchange Program (GIDEP) throughout the program duration. The subcontractor shall review all GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories, GIDEP Agency Action notices, NASA Advisories, ESA Alerts (if applicable), and any informally documented component issues presented by NASA/Lockheed Martin through ATK to determine if they affect the subcontractor products produced for ATK. The Subcontractor shall monitor part procurements and parts drawn from stock for impacts of any of the above alerts or advisories. Parts traceable to date codes and manufacturers listed in alerts shall not be used without additional analysis and ATK’s consent.
In lieu of participation in the GIDEP program, European subcontractors shall be active participants in the ESA Alert System. Participation shall include the assignment of an Alert Coordinator who shall serve as the ESA Alert focal point. The subcontractor shall review all ESA Alerts to determine if any are applicable to hardware in process or delivered for use on the flight system. The subcontractor shall notify the hardware user of any applicable Alerts. Upon request, subcontractors shall provide their internal procedures that describe how participation in the ESA Alert Program shall be performed.

3.4.10 As-Designed Parts List
The Subcontractor shall submit an “as-designed” parts list to ATK for review and approval. The list may be individual engineering parts lists, summarized bills of material, or similar product structure documentation reflecting the design baseline of the flight component, assemblies, and subassemblies to be delivered to ATK. The Subcontractor shall submit the initial as-designed parts list per the SOW, with subsequent submittals in any month that changes occur. The Subcontractor shall submit the final as-designed parts list prior to CDR or at the end of the detailed design phase. The Subcontractor shall submit the parts list(s) in an electronic format in Excel and shall include the following information as a minimum:
- Subcontractor internal part number (if applicable),
- Part description,
- Part manufacturer’s actual part number including all applicable prefixes and suffixes,
- Generic part number or specification number,
- Lot date code,
- Part manufacturer’s name and CAGE code,
- Supplier name (if not the same as manufacturer) and address if not located in the USA,
- Up-screening performed (if applicable),
- Radiation Classification
- Applicable Nonstandard Parts Approval (NSPAR) and Qualification record list
- Quantity used and where used, and
- Comments (any other pertinent information to help ATK justify part usage to the customer if necessary).
3.5 MATERIALS AND PROCESSES PROGRAM
The Subcontractor shall implement a materials and processes program that shall define the selection and control the use of organic and inorganic materials and processes to meet the requirements specified in the following subparagraphs.

3.5.1 General Requirements
The materials and processes selected for flight usage shall meet the requirements of JSC 49774A (Standard Manned Spacecraft requirements for Materials and Processes). When changes of materials, materials application, or materials processing are contemplated, revisions to the as-designed materials and processes list shall be submitted to ATK for review and approval.

3.5.2 Procurement Specifications
Material intended for flight usage shall be procured to controlled procurement specifications. These specifications or drawings shall describe the physical, electrical and environmental requirements and shall identify the Quality Assurance provisions that control the manufacture and acceptance of the material.

3.5.3 Qualification
The Subcontractor shall ensure that the materials and processes used for flight equipment are space qualified. A material or process shall be considered space qualified as long as it is made by the same manufacturer using the same materials, processes, and controls and have had prior successful flight application on missions with comparable durations and environments or qualification test data exist. As an alternative, the Subcontractor may provide a qualification plan to meet the needs of the program in a timely manner to be approved by ATK prior to implementation.

3.5.4 Source Surveillance, Inspection, Audits and Survey
Source inspection and surveillance requirements shall be imposed on suppliers of critical or complex materials and sub-tier suppliers whose process controls are considered to be marginal or program risk is a concern. Audits and surveys shall be performed to monitor conformance to procurement documents and product specifications.

3.5.5 Traceability
Flight equipment material shall be traceable by part number, manufacturer and batch/lot code and to the data supplied in accordance with its specification through the as-built configuration documentation (i.e., manufacturing records for each deliverable item). Any shelf life extension data/info shall be maintained with this traceability.

3.5.6 Materials and Processes List
The Subcontractor shall submit a list of organic materials, inorganic materials and mechanical hardware used in the subcontracted equipment to ATK for review and approval, per the SOW. The list shall provide information specific to each category as described in the following subparagraphs. The Subcontractor shall submit the initial as-designed materials and processes list in accordance with the SOW, and subsequent submittals in any month that changes occur. The Subcontractor shall submit the final as-designed materials and processes list prior to CDR or at the end of the detailed design phase and the as-built shall be provided prior to Pre-ship Review (PSR).
3.5.6.1 Materials Identification and Usage List (MIUL)
The MIUL is an electronic searchable parts, and material identification and usage list that
identifies all Materials and Processes used in the end item, excluding piece part electronics.
(Electronic piece part list are identified in section EEE PARTS PROGRAM.)
The MIUL shall identify the following applicable information:
1. Detail drawing and dash number, and change letter designation
2. Next assemble and dash number, and change letter
3. Drawing source (Contractor or supplier)
4. Material form
5. Material manufacturer
6. Material manufacturer’s designation
7. Material specification
8. Process specification
9. Environment
10. Weight
11. Material grade
12. Standard commercial part number
13. Contractor and contractor number
14. System and subsystem
15. Maximum and minimum temperature
16. Fluid type
17. Surface area
18. Project
19. Document title
20. Criticality
21. Line number
22. Maximum and minimum pressure
23. Overall evaluation or test configuration
24. Test Material Usage Agreement (MUA)

3.5.6.1.1 Non-Metallic Materials
The list for non-metallic materials (including all adhesive, potting, bonding, coating, ink, paint
finish materials, wire insulation, thermal control coatings, thermal blanket materials, and
lubricants) shall contain the following information as a minimum:
a. Material identification by manufacturer,
b. Applicable Federal, Military, Industry, or Subcontractor specification,
c. Type of material, location of material, amount of material, and function of material,
d. Mix ratios (for two or more part materials) and cure schedules for adhesives, coatings,
   sealants, and potting materials,
e. Outgassing data (Percent total mass loss (%TML) and collected volatile condensable
   materials (%CVCM) as defined in ASTM-E595 or equivalent,
f. Glass transition state points and characteristics of conformal coating and other materials
   of concern.
g. Flammability as defined in NASA-STD-6001.

3.5.6.1.2 Metallic Materials
The list for metallic materials shall contain the following information as a minimum:
a. Name of material, identifying alloy number, heat aged condition, and applicable
   specifications (e.g., Aluminum 6061-T6 per ASTM-B209),
b. Surface treatments (e.g., conversion coatings, anodization, Dow Treatments) and applicable specification,
c. Stress corrosion cracking rating per MSFC-STD-3029.
d. Denote fracture critical parts and identify process for nondestructive test.

3.5.6.2 Mechanical Parts Management Plan
The supplier shall submit a Mechanical Parts Management Plan covering nonstructural materials such as fasteners, bearings, studs, pins, rings, shims, valves, springs, brackets, clamps, washers, and spacers fabricated from both inorganic and organic materials. The plan for mechanical hardware shall contain the following information as a minimum:
1. Part Selection and Controlling Specifications
   a. Part description (e.g., nut, bolt, and washer),
   b. Applicable specifications and part number (e.g., NAS620C4),
   c. Physical environment,
   d. Material and finish (e.g., CRES A286, passivation per ASTM-A967),
   e. Stress corrosion cracking rating for metallic materials per MSFC-STD-3029 or other approved method,
   f. Fastener Integrity requirements, including inspections or tests for qualification or acceptance, and lot sampling,
   g. Special handling, packaging and/or storage,
   h. Fasteners used for or in critical applications as defined in the Procurement Specification shall also be required to have met minimum required strength levels by actual test data. Parts shall be qualified to the requirements of the controlling specifications, or describe the process of qualification testing to demonstrate that the part meets its rating. Design Configuration Acceptability- Shall address how the selected parts reliability will meet the operational performance requirements.
Parts Procurement- Shall address how the supplier reviews GIDEP Alerts, plans Source Inspections and/or conducts Destructive Physical Analysis to assure that the parts are acceptable.
The plan shall address how the supplier qualifies Commercial Off-the-Shelf (COTS) hardware for which insufficient parts information is available. In these cases, parts used in COTS hardware may be qualified by environmental and accelerated life testing of a complete COTS assembly.

3.5.6.3 Nonstandard Materials and Processes
Materials or processes that have not been previously flight qualified for the intended application or that do not comply with the guidelines of this document shall be considered nonstandard. The Subcontractor shall identify nonstandard materials or processes with a rationale for use and submit a request for use to ATK.

3.5.7 Metallic Material Requirements and Material Usage Agreements (MUA)
All metallic materials that are exposed to any exterior environments require corrosion inhibiting surface treatments (e.g., chemical conversion coatings, anodize, passivation, paint). Metals and alloys shall not have a propensity towards stress corrosion cracking (SCC), as defined in Table I of MSFC-STD-3029. Metals and alloys in Table II or Table III may be used with an approved Material Usage Agreement (MUA). The MUA form in JSC-49774A should be used to document the planned usage for any Table II or Table III Metals.

3.5.8 Non-Metallic Materials
Non-metallic parts shall not have a corrosion stimulating effect on other materials when exposed for their specific useful lives. Insulation and bond material shall respond within requirements for
the entire range of temperature and strain of the hardware.

### 3.5.9 Materials Selection

Material selection shall be controlled in order to meet the quality, reliability and cleanliness (i.e., contamination control) requirements of the Orion Program. Materials or processes shall be suitable and adequate to perform their intended function over the range of environments as specified in the Performance Specification during the storage and operational life of the hardware. Suitability may be established by heritage design in similar space flight applications, environments, durations, or by test and analysis. Processing criteria shall be selected to assure that all necessary technical and quality assurance requirements exist to control materials processing, hardware assembly, and integration operations.

a. Vacuum stability (Applies to Inhabitable Flight Components, Only): Materials shall contain a minimum of volatile components that are susceptible to outgassing in a space environment. Organic material selected for flight hardware shall meet outgassing requirements in accordance with ASTM-E-595 for total mass loss (TML) shall be less than 1.0% and for collected volatile condensable material (CVCM) shall be less than 0.10%, when tested in accordance with ASTM-E-595. The Subcontractor shall document the outgassing data source. If data are unavailable for the material being used or the materials do not meet these guidelines, the following criteria shall be used to determine if an exception to the vacuum stability requirements is allowed:

1. TML greater than 1.00% is attributable to desorbed water vapor while meeting the %CVCM requirements
2. Using Arrhenius rate equations, the material’s out-gassing properties shall be less than 1.0% TML and 0.1% CVCM at maximum use temperature.
3. The material is hermetically sealed by metallurgical joints or other means.
4. For components/parts using organic materials not meeting the 125°C out-gassing criteria, tests at vacuum of at least 10⁻⁶ and temperatures 10°C above maximum component/part application temperatures may be utilized to determine if the 1% TML and/or 0.1% CVCM criteria shall be satisfied. No change in 0°C witness plates' thermal optical properties ($\alpha$ or $\varepsilon$) shall also suffice as proof that no deleterious out-gassing has occurred at +10°C over application temperatures.

b. Inorganic materials: All exposed inorganic materials shall have a specified surface treatment such that no bare (basis) metal surface is exposed. Selection of proper surface treatments, finish materials, and application methods shall be governed by the type of material used, environment, functional design, handling and storage conditions. Metallic plating and thickness shall be chosen with consideration for the specific application to ensure protection against wear, corrosion, metallic migration, objectionable intermetallics, etc. Component’s mounting surface shall be free from paint or other non-conducting finishes.

c. Propellant compatibility: Metallic and nonmetallic materials that are exposed to propellants for the fluid system or may be exposed to the propellant(s) will not catalyze or accelerate fluid decomposition when tested in accordance with NHB-8060.1. Metallic materials directly exposed to propellants shall not exhibit surface corrosion in excess of a rate of 1 mil per year when tested in accordance with ASTM A279.

d. Corrosion: Metallic materials selected for use on flight hardware shall be corrosion resistant or protected from corrosive environments by finishing per MSFC-SPEC-250A, and prevention of moisture condensation on corrosion susceptible hardware by environmental control or using seals and metallurgical joints. When selecting materials, ground based and flight environments shall be considered. Incompatible couples defined by MIL-STD-889 shall be avoided. Such dissimilar metals may be used in intimate contact, but only if the assembly is protected against galvanic corrosion by a method
listed in MIL-STD-889 and in such a manner as to preclude moisture.

e. Stress corrosion: Metals and alloys that are susceptible to stress corrosion cracking shall be avoided in sustained tensile applications. Applications that use susceptible materials shall be designed such that long term, sustained tensile stress levels experienced are at least 10% below threshold for initiation of stress corrosion cracking. MSFC-STD-3029 or other approved method shall be used as a guide in determining susceptibility.
f. Non-magnetic materials shall be used for all metallic parts except where magnetic parts are essential. All hard magnets such as solenoid cores, motor poles, and any spring steel parts shall be approved by ATK prior to incorporation into the design.
g. Lubricants: used in an intermediate assembly step will be avoided, where possible. For example, silicone spray mold release agents applied to press-fit connectors for ease of assembly shall be avoided for contamination control reasons. All lubricants used, including "temporary" or "secondary" lubricants, must be specified on the organic materials list. Lubricants shall be stable under vacuum environments, shall be stable over the temperature range of operation, shall meet minimum out-gassing rate requirements, shall not degrade in their application and shall not be allowed to contact another lubricant in any application. All fasteners and hardware used in integration/assembly shall be free of all contaminants, especially oils and grease.
h. Composite materials containing graphite fibers shall be treated as graphite in MIL-STD-889. Exterior and exposed materials (primarily thermal control materials) shall be capable of functioning as intended in the ATK charged particle radiation environment predicted for the orbit and mission lifetime.
i. Fasteners shall be procured and managed per JSC-49774A.
j. Flammability: Organic materials for flight use shall be nonflammable or self-extinguishing in air in the application configuration when tested in accordance with NASA-STD-6001. In the event that a material does not meet flammability requirements, the material may be used, if it can be demonstrated that a minimal hazard exists based upon propagation rate, surface area, and degree of containment.
k. Radiation sensitivity and Electrostatic Charging: Exterior and exposed materials shall be capable of functioning as intended in the orbital charged particle radiation environment.

3.5.10 Prohibited Materials
The following materials are prohibited from use in any flight hardware application, unless explicitly approved in writing by ATK:
b. Cadmium (Cd) and/or Zinc (Zn) plating and silver brazing alloys containing cadmium and/or zinc,
c. Any hardware utilizing pure tin (Sn), (i.e., with a purity level higher than 95%),
d. Any hardware containing pure bismuth (Bi) or pure lead (Pb),
e. Corrosive solder fluxes,
f. Corrosive generating silicone sealants,
g. Silicone based thermal grease is to be avoided unless used on heritage hardware and with an explicit method of removal of silicon residue,
h. Silicone materials usage shall be avoided to the greatest extent possible,
i. Use of mercury and mercury compounds,
j. Polyvinyl chloride (PVC).
k. Polymide (Kapton) tape with silicon adhesive, and
l. Teflon (PTFE or FEP) coatings or insulations shall not be used without appropriate review of the application due to potential cold flow, charging, and radiation effects.
m. Silver cased wet slug tantalum capacitors
n. Any non-hermetically sealed part that contains a fluid, such as an aluminum electrolytic
capacitor

o. Solid tantalum capacitors used in a low impedance application of less than 1 ohm/volt unless each part has been surge current tested to the test procedure defined in MILPRF-39003/10B

p. Sealed parts with internal voltages greater than 200 volts that are used in a vacuum environment and have a maximum leak rate which will allow the internal cavity pressure to reach 50 torr over the parts mission life

q. Parts with internal plating of pure tin

r. Use of cartridge style fuses in a vacuum environment with greater than 50 volts DC applied

s. Switches, relays bimetallic thermostats, and other mechanical contact devices:

t. Used in a voltage application for which they were not specifically qualified and proven

u. With higher rated contacts used in a low voltage or current application unless specifically recommended by the device manufacturer

3.5.11 Process Criteria
The Subcontractor shall assure that the technical and quality assurance requirements necessary to control materials processing, assembly, and integration operations exist and are implemented. The selection and use of processes shall be subject to the applicable guidelines specified herein.

a. Heat Treatment: Heat treatment of metallic parts shall be in accordance with the following specifications, as applicable, and subject to the applicable guidelines specified herein:

1. Aluminum Alloys: SAE-AMS-2770, SAE-AMS-2772
2. Nickel Alloys: SAE-AMS-2774
3. Steels: SAE-AMS-2759
4. Titanium Alloys: SAE-AMS-H-81200A

Heat treatments not included in these specifications may be used, provided sufficient test data are available to substantiate that the heat treatment process improves the properties of the specific alloy without increasing any susceptibility to degradation and is approved by ATK. Test coupons shall be heat-treated at the same time and in the same furnace as the heat treated production parts and maintained for reference. Control records shall be maintained for the time and temperature of processing the heat-treated parts. Ferrous materials heat treated to high tensile strengths (>160ksi) and then cleaned in an acid bath or which require plating shall be baked for 24 hours at 132°C ±2°C to alleviate hydrogen embrittlement. Total decarburization shall not be present on any machined finish surface. Partial decarburization may be present to a maximum depth of 0.003 inch unless otherwise specified.

b. Metallurgical Joining: Suitability of the equipment, processes, supplies, and supplementary treatments and procedures selected shall be demonstrated by qualification testing of welded or brazed specimens that are representative of the materials and joint configurations used for production.

c. Dissimilar Metals: Dissimilar metals shall not be welded unless approved by ATK.

d. Brazing: Brazing operations shall be performed in accordance with AWS-C-3.3 or to an equivalent Subcontractor procedure. Fluxes shall be thoroughly cleaned from all brazed joints. A silver nitrate test in accordance with AWS-C-3.3 or an equivalent Subcontractor procedure shall be performed to verify joint cleanliness. Representative brazed joint test coupons shall be processed in the same manner as the production part joint and maintained for reference.
e. **Joint Inspection:** All welded joints and repair welds shall be dye penetrant inspected in accordance with ASTM-E1417 or magnetic particle inspected in accordance with MILSTD-1949 or equivalent Subcontractor procedures. All structural welded joints (including pressure system weld joints), or repair welds, and brazed joints shall be dye penetrant inspected or radiograph inspected in accordance with ASTM-E1742 or equivalent Subcontractor procedures. Welding shall be in accordance with NASA-STD-5006.

f. **Surface Preparation:** All surfaces to be bonded, coated, or sealed shall be properly prepared and cleaned to defined and proven process methods to assure adequate adhesion of adhesive, thermal control coatings, or sealant to the designated surfaces.

g. **Soldering and Electronic Assembly:** Soldering and electronic assembly shall be performed to IPC/EIA J-STD-001 (Class 3 with Space Addendum), NASA-STD-8739.3, or ATK-approved equivalent.

h. **Crimping and Wire Harnesses:** Crimping and Wire Harnesses shall be per JPR-8080.5 (with the exception that NASA-STD8739.4 is not required), or an ATK-approved equivalent.

i. **Printed Circuit Boards:** Printed Circuit Board Qualification and Performance shall be per IPC-6011 (Class 3) and IPC-6012.

j. **Conformal Coating and Staking:** Conformal Coating and Staking shall be per NASASTD-8739.1, or ATK-approved equivalent.

k. **Electro-Static Discharge (ESD):** See Section **Electrostatic Discharge (ESD) Protection.**

l. **Fasteners:** The installation of titanium fasteners and associated parts shall meet the requirements of MSFC-STD-557. Fastener locking requirements are specified in JSC-49774A section 4.6.4.1.

3.5.12 **Corrosion Control - Compatibility of Process Materials**
The Subcontractor shall insure that processes or materials will not have any deleterious effects on metallic materials or their properties. As an example, chlorinated and sulfonated fluids and solvents shall not be used with titanium and nickel alloys. All flux materials used for soldering operations on printed circuit board assemblies shall be removed to prevent corrosion and/or contamination.

3.5.13 **Adhesive Bonding**
Structural Adhesive Bonding shall meet the requirements of MSFC-SPEC-445A; with the exception of paragraph 3.1.1.1.

a. **Surface Preparation:** The Subcontractor shall insure all surfaces to be bonded, coated, or sealed shall be properly prepared and cleaned to defined and proven process methods to assure adequate adhesion of adhesive, thermal control coatings, or sealant to the designated surfaces.

b. **Curing:** Processes shall allow for adhesives and coatings to cure at ambient conditions. An accelerated cure for materials is generally not recommended unless previously proven and standardized for a certain material.

c. The supplier shall document the mix ratio and cure times of all adhesive mixes used on deliverable hardware.
3.5.14 Age Sensitive Material
Limited shelf life materials shall be so marked with expiration date and controlled in accordance with Subcontractor’s standard procedures. These materials shall not be processed beyond the stated shelf life expiration date unless based on test information supplied by the manufacturer and/or obtained from Subcontractor internal test methods. Test information used to extend the shelf life of any material used shall be maintained by the subcontractor as a quality record. Appropriate mix, cure, and batch information is retained with the product build documentation for traceability purposes.

3.6 SAFETY PROGRAM
The purpose of the Safety Program is to assure that the equipment is designed, manufactured, tested, stored, delivered, and operated in such a manner that the risk of hazards to personnel, flight hardware, and facilities during all manufacturing, test, launch and mission phases are minimized to an acceptable level.

3.6.1 Safety Requirements
The subcontractor’s products shall be compliant with applicable requirements with respect to the hardware and software supplied by them for the program. Design Safety requirements shall be established and followed to minimize hazards.

3.6.2 Safety Responsibilities
The equipment designs and procedures shall be examined to identify hazardous operations (including those initiated by inadvertent software commands), hazardous equipment (GSE), assemblies, or materials, initiate hazard reports, monitor the resolution of deficiencies, and ensure that results of safety and hazard analyses are implemented in the designs.

3.6.3 System Safety Hazard Analyses
Safety analyses as described in the SOW shall be performed in accordance CxP-02012 to systematically analyze the conditions, which may create and/or propagate hazards. The safety and hazard analyses shall be initiated early in the design phase and kept current throughout the development phase. Identified hazards which result in a Critical or Catastrophic risk to personnel, the Crew Exploration Vehicle (CEV), the flight equipment, the test equipment or facilities shall be modified to reduce the risk to Marginal or Negligible severity or be so unlikely that it can be assumed the hazard will not occur.

The Subcontractor shall document all hazards in a hazard analysis and shall submit the hazard analysis to ATK for review and approval in accordance with the Statement of Work. Any changes to design or operation which impact safety shall cause the analysis to be updated and resubmitted to ATK.

3.7 CONFIGURATION AND DATA MANAGEMENT PROGRAM
The Subcontractor shall implement a Configuration and Data Management (CDM) system, which meets the intent of MIL-HDBK-61A or equivalent industry standard. This system shall be documented and the Subcontractor shall provide the documentation to ATK.

3.7.1 Major Program Elements
The CDM program shall comprise the following major elements:
 a. All hardware and software changes controlled by approved change control documentation,
 b. Approved configuration defined by specification, part number, serial number, and revision level,
 c. As-built configuration documented and verified at acceptance by Quality Assurance and
Software Product Assurance, as appropriate,
d. Surveillance, guidance and configuration control maintained over sub-tier
Subcontractors and suppliers,
e. Maintain program records and documentation,
f. Maintain program documentation originals in a central, secure, and controlled access
file.

3.7.2 Design Change and Exception Classifications

Design changes and exceptions shall be classified as follows:

a. Class 1 is defined as a change affecting the form, fit, or functions of the item and
therefore impacts the technical, cost, and schedule baseline of the next higher level
assembly. For all proposed Class 1 changes, an Engineering Change Proposal (ECP)
shall be submitted to ATK for review and approval. The Subcontractor shall generate
an appropriate Engineering Change Notice (ECN) upon approval of the proposed Class
1 ECP. Any change after design acceptance by ATK shall be submitted to ATK for
concurrency of classification. Any submitted Class 2 change, which is deemed Class 1
by ATK, shall be resubmitted as an ECP. If the ECP is rejected any modifications
made to hardware or software as a result of the change shall be removed at no cost to
ATK.

b. Class 2 is defined as a change affecting hardware or software that does not qualify as a
Class 1 change. A Class 2 change shall be implemented after CCB approval and
submitted to ATK for information only.

d. Deviation is defined as a written authorization granted by ATK before the
implementation of the requested change from a requirement.

e. Waiver is defined as a written authorization by ATK to accept an item which departs
from specified requirements but is considered suitable for use “as is” or after rework by
an approved method.

The Subcontractor’s document format is acceptable.

3.7.3 Acceptance Data Package

For each Contract End Item (CEI) the Subcontractor shall submit an Acceptance Data Package
(ADP) to ATK upon satisfactory completion of final acceptance testing and inspection in
accordance with the requirements of the SOW. A comparison of the As-Designed versus As-
Built configuration shall be performed and the differences shall comprise a portion of the ADP.
The ADP shall also contain all Acceptance, Proto-flight, and Qualification Test data and reports,
as-run test procedures, Certificates of Compliance/Conformance, Material Review Board (MRB)
Reports, Failure Analysis Reports, Deviations, and Waivers, version control history of software,
requirements verification matrix, test hours at box level, and any Open Items hardware
shortages and any data that serves as objective evidence of requirements compliance. The
supplier shall take multiple photographs of all interior/exterior workmanship of each flight unit,
and these photos shall be included with the ADP. The photos shall be of sufficient resolution to
show workmanship quality detail.

3.8.2 Purchasing Control and Incoming Inspection

The Orion Program is a Manned NASA Space Program. The following Quality Clause statement
shall be added to all procurements, in addition to the regular Quality Clauses that define the scope of work:

“Manned Space Flight-
Articles ordered in this contract are for use in Manned Space Flight. Materials, manufacturing, and workmanship of the highest quality standards are essential to astronaut safety. If you are able to supply the desired items with a quality which is higher than that of the items specified or proposed, you are requested to bring this fact to the immediate attention of the purchaser. This clause will be inserted in all subcontracts and purchase orders for such items down to the lowest tier.”

Procedures and responsibility for controlling the quality of procured components, parts, material, and services are defined and implemented in accordance with the Subcontractor’s Quality System Manual and Procedures.
The overall objective is that each procurement from outside sources be planned, reviewed, and approved by Source Acceptance personnel, and controlled utilizing the following requirements as a minimum:

a. Assure clear definition of requirements in source control documents, specifications, engineering drawings;
b. Purchase requisitions and purchase orders include all appropriate drawings, specifications, requirements, special handling instructions, and proper receiving inspection codes/instructions;
c. Selection, control, and review of qualified subcontractors and suppliers through site surveys, audits, and maintenance of a supplier rating system utilizing previous performance history results;
d. Agreement on quality assurance and verification methods (i.e., source inspections, test data review, DPA, etc.);

e. Plans, controls, and records for verification of purchased components; parts, materials, and services provide acceptable product quality and reliability for mission success.

Incoming items shall not be accepted for use on the Program unless they meet the requirements of the technical documents, the subcontract or purchase order, or other program requirements. The Subcontractor shall maintain records of inspections performed on parts and materials received from suppliers.

3.8.3 Contractor Furnished Equipment (CFE)/Government Furnished Equipment (GFE)
The Subcontractor shall establish and maintain documented procedures for controlling equipment and material supplied either by ATK and/or ATK’s customers or suppliers for incorporation/test of the deliverable products. Any nonconforming CFE/GFE shall be subject to MRB action. The Government can review the subcontractor’s procedures for GFE. The procedure shall include the following provisions:

a. Examination of the item and its packaging to detect any damage in transit,
b. Determine correct quantity, completeness, and identity as specified in the shipping documents,
c. Check for presence and completeness of any required documentation,
d. Verify any required ATK or customer/Government certification,
f. Report on any damages at receipt or during use,
g. Verify ATK or customer/Government inspection,
h. Appropriate inventory, storage and handling.
3.8.4 Control of Inspection, Measuring, and Test Equipment
The Subcontractor shall maintain objective evidence for certification of calibration for inspection devices and measurement and test equipment used to produce, inspect, and test deliverable flight hardware. Records certifying that tests have been performed as well as the parametric results of such tests are maintained for each piece of equipment and are made available to ATK, upon request. The Subcontractor shall maintain a documented metrology system compliant to U.S. or International standards to validate equipment for conformance to specifications. The Subcontractor's system shall meet the requirements of ISO10012 or ANSI/NCSL-Z540-1. Traceability to the recognized national and/or international calibration standards is maintained and recorded. The system provides for the selection, approval, calibration, maintenance, control, and recall of inspection and test measuring equipment on an on-going basis.

3.8.4.1 Control of Accuracy
Inspection, Measuring, and Test Equipment (IM&TE) is controlled to assure that supplies and services presented to ATK for acceptance have been tested with equipment of sufficient accuracy to verify conformance to prescribed performance requirements. Subcontractor maintains a calibration system in accordance with their Quality System Procedures with controls to assure accuracy and traceability to National or International measurement standards. Test readiness documentation or test procedures shall include measurement tolerances, a listing of required equipment, whether that equipment requires calibration, and provisions for listing actual equipment used. Measuring equipment shall have precision nominally an order of magnitude or greater than that required for the measurement data, not less than a factor of four for typical measurements, and five for critical measurements.

3.8.4.2 Indication of Calibration Status
Individual measurement and test equipment will be periodically recalled to verify dimensional and operational characteristics as required by the Metrology Department. The calibration status of each measurement tool or piece of test equipment is identified by a readily visible label that includes the re-calibration due date, the assigned control number used for identification and traceability purposes, and the name of the Metrology technician who performed the calibration.

3.8.4.3 Production Tooling Used as Media of Inspection
Production tooling used as a medium of inspection is initially proven for accuracy at the time of receipt (or manufacture, if produced by Subcontractor) and prior to release to production. Accuracy is proven by tryout of the tool in the designated work area with subsequent Product Assurance inspection using an independent, previously calibrated instrument. When acceptable, the tool is assigned an identification control number, a calibration record is prepared, a calibration status label is attached, and the tool is released to the work area for usage. Unacceptable tools are rejected by the Product Assurance inspection. All tooling used as a media of inspection is subject to periodic recall and re-verification of accuracy. The periodic verifications are controlled through calibration due dates established by the Metrology Department.

3.8.5 Foreign Object Debris (FOD) Controls
The subcontractor shall maintain a Foreign Object Debris (FOD) Control Program in accordance with NAS-412. Process control requirements for metallurgical, chemical, cleaning, bonding, welding, brazing, coating, plating, painting, soldering, radiography, ultrasonic, magnetic particle detection, and other special processes shall be developed and reflected in the Subcontractor process specifications. Processes, including electrostatic discharge (ESD) protection/prevention, contamination control, and special environmental control shall be
specified in design drawings and specifications. The Subcontractor shall maintain the deliverable hardware and lower level components during all phases of manufacture, inspection, test, and storage in an environmentally controlled area with temperature, humidity, cleanliness, and ESD prevention controls in-place. The area used for temporary storage of the flight parts/material shall prevent mechanical and electrical degradation of the items. Full traceability shall be maintained and special attention given to those items requiring special storage conditions, (e.g. electrostatic discharge sensitive components, nitrogen storage, etc). A quarantine item shall be segregated from conforming items in order to allow the segregation of discrepant/failed items. The traceability of the quarantined items to the corresponding discrepancy or nonconformance reports shall be maintained.

Flight hardware shall be maintained in visibly clean assembly areas. Handling shall be minimized after final testing, and then only with clean, lint-free gloves. Product packaging shall also maintain cleanliness.

### 3.8.9 Workmanship Standards

The subcontractor shall document its Workmanship Standards, and they shall be available for review (on-site) by ATK, ATK’s Customer, and the Government. Standards of workmanship shall be defined directly in hardware specifications and/or assembly drawings or by reference to Subcontractor, Industry, or Government documents. Soldering workmanship standards shall be as defined in the documents IPC/EIA J-STD-001C (With Space Addendum, Performance Class 3), NASA-STD-8739.3, or ATK-approved equivalent. Cabling and harness workmanship standards shall be defined in JPR-8080.5 or equivalent. General workmanship shall meet the requirements of MIL-HDBK-454 or equivalent. Rigid PWBs must be procured and manufactured to MIL-PRF-31032 or IPC-6012B Class 3/A, and rigid-flex PWBs shall comply with MIL-PRF-31032 or IPC 6013 or equivalent. PWB design shall be in accordance with IPC-2221 or equivalent Circuit cards and other electronic assemblies shall be conformal coated per NASA-STD-8739.1 using a low outgassing material such as Parylene, Arathane (Uralane) or equivalent; any exceptions to the conformal-coating requirement must be approved by ATK. Deviations to this requirement may be acceptable with ATK approval. The conformal coating shall allow reasonable repair or rework. Subcontractor and supplier workmanship standards and procedures employed on the program shall be made available to ATK, upon request, for review. The supplier shall take multiple photographs of all interior/exterior workmanship of each flight unit, and these photos shall be included with the EIDP. The photos shall be of sufficient resolution to show workmanship quality detail.

### 3.8.11 Manufacturing and Test Operations

Fabrication, assembly, and test operations shall be performed in accordance with manufacturing planning documentation. ATK reserves the right to add Mandatory Inspection Points (MIPs), Test Readiness Reviews (TRRs), and Pre-Shipment Review (PSR) as defined in the SOW. Subcontractor personnel responsible for performing special processes shall be certified. Records of certified individuals shall be maintained. Inspection personnel shall be thoroughly familiar with the requirements to be met in order for the process to be properly accomplished. Mate/de-mate logs shall be maintained for all flight connectors showing dates, operator, torque. Connector savers shall be used, wherever practical. Final mates and torqueing of fasteners shall be witnessed by QA, shall be clearly documented, and torque-striping or lockwiring shall be used on all torqued fasteners.
3.8.12 Final Acceptance Test
Acceptance, protoflight, or qualification tests (environmental and functional) shall be carried out as required by Subcontract documentation (SOW, Performance Specification) and shall be implemented according to procedures reviewed and approved by ATK in advance of their performance. A minimum of 200 operating hours shall be achieved on each electronic flight article prior to delivery, and the last 100 hours shall be failure-free. Compliance with this metric shall be clearly documented in the End Item Data Package (EIDP).
Subcontractor Quality Assurance shall ensure that test operations are performed in compliance with these plans and procedures by the following methods:
  a. Work area surveillance,
  b. Test surveillance.
The Subcontractor shall notify ATK of Qualification testing and final acceptance test activities prior to the beginning of the tests. The Subcontractor test conductor shall initiate a Nonconformance/Test Failure Report as described in section 3.9 and notify the cognizant ATK engineer within 24 hours in the event that an out-of-specification condition, anomaly, or variation/deviation to the test procedure occurs. Subcontractor Quality Assurance personnel shall review the test documentation to ensure that such occurrences have been noted and test failure reports and analyses are generated.

3.8.13 Test Specifications, Procedures, and Data Sheets
Final acceptance test procedures shall indicate the parameters to be tested, the calibrated equipment to be used, the environment in which the test is to be conducted, the test conditions and levels, and the acceptance criteria. Test data sheets shall become part of the EIDP documentation and shall be retained as objective evidence of conformance to the requirements.

3.8.14 CEI Nameplate and Product Marking
The Contract End-Item (CEI) shall be marked for identification. The marking method shall be permanent and shall remain legible after exposure to the test environments of the Performance Specification. Materials and processes used for marking shall comply with the requirements of section MATERIALS AND PROCESSES PROGRAM. Paper decals shall not be used. The identification shall include the following as a minimum:
  a. Nomenclature:
  b. ATK Product Specification Number:
  c. Serial number
  d. Contract Number:
  e. Manufacturer’s Name or Trademark and CAGE Code.
  f. Date of Manufacture (month/year). The date of manufacture is typically the delivery date.
  g. Manufacturer’s Part Number, Serial Number, and Revision Level.

Hardware or equipment that is not suitable for use in flight and that could accidentally be substituted for flight or flight spares shall be red striped with material compatible red paint to prevent such substitution. In the event the hardware is too small to be easily striped, or if test performance would be affected by striping, a conspicuous red tag marked “NOT FOR FLIGHT USE” shall be attached. Wires and cables for hardware shall not be identified by hot stamping directly onto primary or secondary (shielded) insulation.

3.8.15 Protection, Packing, Handling, Marking, and Shipment
Engineering drawings, procedures, or specifications shall be generated which define the
instructions and requirements for the preservation, packaging, handling, cleanliness preservation, storage, and shipping of flight articles and materials. These requirements, or special requirements invoked via the subcontract SOW, shall be incorporated into work authorizations, planning documents, and operating procedures to ensure that delivered products are protected against damage and deterioration as well as meet the environmental control and contamination control requirements.

3.8.15.1 Protection and Preservation
Items subject to deterioration or corrosion by contact with air, humidity, or other factors during handling, construction, temporary storage periods, or transportation shall be cleaned and protected by a process designed to minimize exposure to the detrimental condition. Storage areas shall be well lit and suitably environmentally controlled. Electrical connectors shall be closed with suitable ESD protective caps or plugs, or connector savers with end caps. During test operations (or other activities requiring electrical connection to flight interfaces) use of connector savers is required to the maximum extent possible. The Subcontractor shall be responsible for the preservation and packaging of the deliverable items in a manner that shall prevent contamination, corrosion, deterioration, and physical damage and insure safe delivery in good condition in accordance with MIL-STD-129 or equivalent. Packaging of the unit for shipping and storage shall insure that condensation on the unit does not occur. Do not use “pink poly” (polyethylene) for bagging or packaging.

3.8.15.2 Electrostatic Discharge (ESD) Protection
The Subcontractor shall maintain a NASA-STD-8739.7, ANSI/ESD-S20.20 or equivalent ESD program to protect electronic parts, assemblies, components, subsystems, systems, and spacecraft from electrostatic discharge during handling, storage, and transportation that could damage or degrade the reliability of the deliverable items including critical ground support test equipment. Electrical connectors shall be closed with suitable ESD static dissipative dust caps or plugs, or connector savers with ESD end caps.

3.8.15.3 Contamination Control, Cleanliness Control, and Clean Room Requirements
To comply with strict contamination and cleanliness controls, more stringent clean room requirements may be imposed for specific components in accordance with the applicable SOW and Performance Specification.

3.8.15.5 Packing and Shipment
Shipping containers shall identify the location of the documentation package. Subcontractor QA representatives shall inspect the packaging of the items for shipment and shall stamp the shipping paper as the objective evidence of this activity. Items shipped shall be subject to final packaging and inspection, which shall ensure that:
a. Articles are complete and assembled as required, and have satisfactorily passed applicable inspection and test,
b. Accompanying documents are complete, are properly identified, indicate the inspection status, and contain traceability information,
c. Article have preserved and packaged in accordance with the applicable procedures and requirements which fully protect the unit during transport,
d. Packaged articles have been identified and marked in accordance with the requirements to ensure safe arrival and ready identification at the destination,
e. “Pink Poly” material shall not be used with delivered hardware.
f. Approved metallized ESD-protective bags shall be used for all EEE hardware,
g. Handling devices, shipping containers, and transportation vehicles are suitable for the articles involved,
h. Loading and transportation methods conform to the applicable requirements.

i. Shock indicators are employed that shall provide indication of damaging or degrading accelerations (shock/impact) to the flight hardware. Three indicators shall be used and arranged orthogonally on both the inside package and external shipping container. Shock indicators shall be rated to the requirements of the component being shipped.

j. Moisture indicators that shall provide evidence of humidity levels beyond the specification level allowed.

k. Gaseous nitrogen (N2) purge systems for equipment that require such cleanliness or contamination control, and

l. Heat from foam-in-place packaging material shall not exceed temperature rating of deliverable hardware.

3.8.15.6 Marking and Identification

The outside of the container shall show arrows indicating the correct “up” orientation of the container and, where applicable, markings of “ESD”, “Clean Room Open”, and/or “Fragile” warnings. If it is required that the container be opened in a clean room, a Notice shall be marked clearly on the top face of the shipping papers attached to the container. The shipping packages/containers shall contain documents with the following information:

a. Addressee at ATK,

b. Content (part number, serial number, description, and quantity),

c. Measured Weight (gross and net) in kilograms (on container),

d. Overall size (on container),

e. Contract number and purchase order,

f. “Fragile” (when applicable) on container,

g. ATK Address,

h. “Flight” or “Nonflight” indication, and

i. ATK Authorization to ship or reference number.

3.8.16 Internal Quality Audit Report

The Subcontractor shall conduct internal Quality Audits to determine whether the quality management system and processes conforms to the requirements of this document, and to the requirements established in the Statement of Work and Performance Specifications are effectively implemented and maintained.

The Subcontractor’s QA Audit Report shall document the findings from audits of processes, procedures and operations which implement the quality program. Each audit shall include examination of operations and documentation, comparison of actual operations to established requirements, requests for Corrective and Preventative Action, identification of root causes of problems, and follow-up to verify that Corrective Actions are implemented.

The QA Audit Report shall include the date performed, process audited, QA involvement, evaluation criteria, findings, recommended corrective actions and follow up schedule for corrective action.

The responsibilities and requirements for planning and conducting audits, and for reporting results and maintaining records shall be defined in a documented procedure. QA Audits may be conducted by the Subcontractor or by a qualified party on behalf of the Subcontractor. The management responsible for the area being audited shall ensure that actions are taken without undue delay to eliminate detected nonconformities and their causes. Follow-up activities shall include the verification of the actions taken and the reporting of verification results.

ATK may review the Audit Reports at the supplier’s facility, or conduct audits and surveillances of the Subcontractor’s quality program implementations to verify the quality requirements described in this document, the Statement of Work, and the Performance
Specification are being met.

3.8.17 Training
Personnel working in fabrication, assembly, inspection, test, and integration operations at the Subcontractor shall be properly trained, either formally, on-the-job, or a combination of both. Subcontractor employee training records shall be maintained as part of personnel records and shall be available for review. Performance is monitored periodically to identify and remedy training issues when the quality trends of the hardware becomes unacceptable, when new technology is being implemented, when technical job skills require upgrading to effectively perform a job function, and when cross-training an employee to perform a new job function is requested.

3.8.18 Servicing
Post-delivery service, operation, training, and/or maintenance of delivered hardware and software products shall be handled through the original contract award, an amendment to the contract, or through a separate contract SOW. The scope of the work activities to be performed is negotiated to ensure Subcontractor and ATK agreement and understanding. Product Assurance activities ensure that service processes are performed under defined and controlled guidelines as described in the Subcontractor’s Quality System Manual.

3.9 NONCONFORMANCE AND FAILURE CONTROL PROGRAM

The Subcontractor shall have an effective closed loop system for failure reporting on both hardware and software anomalies. The system shall, as a minimum, provide for:

a. Timely recognition, documentation, and processing of suspected and confirmed failures and anomalies,
b. Timely notification and involvement of ATK (within 24 hours of occurrence),
c. Notification of failures at Subcontractors,
d. QA approval of all troubleshooting plans prior to implementation,
e. Precise determination of root cause of failures,
f. Effective review function by associated Subcontractor disciplines,
g. Appropriate disposition of flight article,
h. Proper documentation and physical analysis,
i. Adequate corrective action to prevent similar failures,
j. Customer involvement as a voting Class I MRB and FRB member and approval authority for all failures after first power-on, and
k. A rigorous methodology to address the risks of unverified or “ghost” failures. An unverified or “ghost” failure is an anomaly that cannot be reproduced, and thus cannot be critically analyzed to determine root cause. Orbital shall be a voting FRB member in dispositioning all unverified failures, regardless of severity or perceived importance.

3.9.1 Nonconformance Control
A nonconforming item has one or more proven characteristics that departs from its requirements, performance specifications, assembly drawings, parts list, or any other approved engineering documentation. Nonconformance control shall provide for the segregation and identification of nonconforming items. The inspection status and identification of such nonconforming items shall be documented at the point and time of discovery in the item’s document folder and shall be immediately subject to review. Non-conformances shall be reported to ATK within 24 hours of their occurrence; return receipt email to ATK Quality Engineer and the Subcontract technical manager is an acceptable form of this
communication. ATK shall maintain Class 1 approval authority on MRB/FRB actions. Class 2
MRB/Authority is granted to the supplier. Nonconforming items dispositioned by ATK as
acceptable, or accepted after corrective actions have been implemented, may be subsequently
treated as conforming items.

3.9.1.1 Material Review Board (MRB)
The Subcontractor’s shall use their own database for tracking MRB/FRB activity, and shall
review each nonconforming item and classify the disposition as either Class 1 or 2 MRB.

Class 1 MRB Requires ATK Approval. Class 2 MRB Requires the Supplier Approval only, but
must be available for review, and must be included in the End Item Data Package.

Class 1 Material Review Board Authority

The supplier shall submit all Class 1 MRB’s to ATK for approval. Class 1 Material Review
authority is for articles or characteristics contained in supplier drawings, specifications or
Purchase Agreements that are requirements of ATK, Orbital, Lockheed Martin or NASA, and do
have a direct effect on the specified requirements. If the supplier is uncertain as to the effect on
specified requirements, the concurrence of the ATK Quality Representative shall be obtained.
Material Review records shall be made available to ATK Quality Assurance upon request, and
shall be included in the End Item data Package. Class 1 MRB Reports require Government
concurrence prior to submittal to ATK.

Class 2 Material Review Board Authority

The supplier is delegated Class 2 Material Review authority for all article characteristics
contained in supplier drawings and specifications that are not specified requirements of ATK,
Orbital, Lockheed Martin or NASA drawings or Purchase Agreements; and do not have a direct
effect on the specified requirements. If the supplier is uncertain as to the effect on specified
requirements, the concurrence of the ATK Quality Representative shall be obtained. This
authority does not extend to the use of Material Review Board (MRB) for the purpose of
changing engineering criteria, which can be accomplished by drawing change. This delegation
is subject to change at any time by ATK, and can be rescinded at any time by written
notification from ATK. Material Review records shall be made available to ATK Quality
Assurance upon request.

All nonconforming material for Customer and Government Furnished Material (Regardless of
Classification) requires Approval by ATK or the Government prior to any MRB disposition.

If during hardware review ATK deems that an incorrect delegation of Class has been made to a
nonconformance which results in the unacceptable use and subsequent replacement of said
part(s), the Subcontractor will be responsible for all costs associated with replacement and any
testing.

3.9.2 Failure Review Boards (FRB)
A failure is any test anomaly, regardless of apparent magnitude. ATK approval shall be
required for resolution of any failures during or after acceptance, protoflight, or qualification
testing, including retest requirements. The Subcontractor shall conduct Failure Review Board
(FRB) meetings to review failure reports and to decide the appropriate corrective action. The
FRB shall ensure the following:
a. Status of failure investigation is reported bi-monthly, and more frequently as shipment of hardware nears, and a plan of action for open reports is established and carried out,
b. Root cause of failure is determined or, if an exact cause cannot be determined, that a rigorous failure analysis has been conducted,
c. Effectivity or other impact upon the hardware (e.g., over-stressed parts) is determined and actions are initiated as appropriate,
d. Each failure report and failure analysis report shall be reviewed by ATK.

If the Subcontractor experiences failures during qualification, protoflight, or acceptance testing, the Subcontractor shall generate a failure report and notify ATK within 24 hours of the failure occurrence. Presence of an ATK representative during testing shall constitute notification. ATK shall have approval authority of final FRB results. ATK concurrence with cause and corrective action findings is required.

All unverified failures (exact cause is not known) during acceptance, protoflight, or qualification testing at board level and above shall be reviewed and evaluated by the Subcontractor. Unverified failures at board level and above shall be reported to ATK. Actions regarding any unverified failures at the unit level shall be submitted to ATK for review and approval.

3.9.2.1 Failure Investigation
Each failure/anomaly shall require an investigation as to root cause, rework or repair action, and corrective action. The investigation shall be performed at the lowest level necessary to identify the failure mode. Supporting documentation resulting from each analysis and investigation shall be attached to and made a part of the failure report. Copies of each completed failure report and supporting documentation shall be furnished to ATK. ATK’s approval shall be required for final disposition, re-entrance into acceptance, protoflight, or qualification test and test re-start location.

3.9.3 Corrective and Preventive Action
The Subcontractor shall aggressively correct and proactively approach any item adversely affecting performance, cost, or schedule. The Subcontractor shall establish and maintain documented procedures for implementing corrective and preventive action.

Any corrective or preventive action taken to eliminate the causes of an actual or potential nonconformance shall be to a degree appropriate to the magnitude of problems and commensurate with the risks encountered.

The Subcontractor shall implement and record any changes to the documented procedures resulting from corrective and preventive action.

3.9.3.1 Corrective Action
The procedures for corrective action shall include:

a. Effective handling of customer complaints and reports of the nonconformance,
b. Investigation into the cause of the nonconformance relating to product, process, and quality system and recording the results of the investigation,
c. Determination of the corrective action needed to eliminate the cause of the nonconformance,
d. Application of controls to ensure that the corrective action is taken and that it is effective.

3.9.3.2 Preventive Action
The procedures for preventive action shall include:
3.10 SOFTWARE QUALITY ASSURANCE PROGRAM
The only applicable flight software/firmware on the Orion LAS is in the Attitude Control Motor. If applicable to the product, the Subcontractor shall implement a Software Product Assurance (S/W PA) Program with the intent to verify that all software requirements are flowed down, implemented, and verified appropriately. The objectives of this program shall be to establish basic requirements for the design, development, configuration control, test, verification, problem reporting, safety, storage and maintenance of software developed for the subcontract. The Subcontractor shall submit S/W PA Plans in compliance with the SOW. Software and firmware are both referred to as software for the purposes of this document. The Subcontractor’s S/W PA Program shall apply to:

a. **Flight Software**: This category includes any software that will be integrated into ATK software as well as software that will be embedded in any flight component supplied by the Subcontractor,

b. **GSE Software**: This category includes software associated with acceptance, protoflight, or qualification testing of the component or software supplied to support Spacecraft Integration and Test,

c. **Design Support Software**: This category includes software associated with the design, development, testing, or production of deliverable software.

3.10.1 Audits on Software Quality Assurance
The Subcontractor shall perform Software Quality Audits and reports in accordance with NASASTD-8739.8, and participate in key milestone activities, as well as support Software Product Assurance audits performed by ATK, as required.

The Software Quality Audit Report shall include:

a. Date performed
b. List SQA personnel involved in the audit, and number of hours spent
c. Evaluate/audit criteria including which software process or product is being reviewed, and which established procedures are they being compared to
d. Findings, including detected problems, with reference to the Software Problem Report
e. Recommended Corrective Actions
f. Date for follow-up
g. Status on any remaining corrective actions from previous audits

3.10.2 Software System Safety
If the subcontracted item contains Safety Critical Computing Systems Functions (SCCSFs), the Subcontractor shall assure that the software is analyzed and corrective actions taken to ensure that the software design and testing.

The Subcontractor shall provide sufficient access into the software development approach utilized in the components regarding safety critical software. Examples of SCCSFs include:

a. The priority structure of fault detection and safeing or correcting logic shall be considered safety critical. Software units or modules handling or responding to these faults shall be designated as SCCSFs.
b. Interrupt processor software, interrupt priority schemes and routines that disable or enable interrupts shall be considered SCCSFs.
c. Software-generated signals that have autonomous control over safety critical hardware shall be designated as SCCSFs.
d. Software-generated signals that have been shown through detailed analyses, such as Fault Tree Analyses, to directly influence movement of hardware components or initiate safety critical actions, such as arm command for thermal wax actuator solar array deployments or satellite-to-launch vehicle separation, shall be designated as SCCSFs.
e. Software-generated outputs that display the status of safety critical hardware systems shall be designated SCCSFs and shall, where possible, be duplicated by non-software generated output.
f. Software used to compute safety critical data shall be designated SCCSFs. This includes applications software that may not be connected to or control a hardware system, such as stress analysis programs.

3.10.3 Software Configuration Management
The Subcontractor shall implement a Configuration and Data Management (CDM) system that meets the intent of SEI-CMMI Level 3, or equivalent industry standard approved by ATK. This system shall be documented and the documentation provided to ATK with the Product Assurance Plan or separate Software PA Plan. Build logs shall be maintained, to allow traceability of version numbers used at each step in the product flow. The change control system shall require a full description of each change and the reason for each change. If applicable, the nonconformance record number shall be included in the change description.

3.10.4 Software Quality
The subcontractor shall have an independent Software/Project quality representative whose responsibility is to ensure that all requirements are properly documented, that a verification matrix is developed to assure all requirements are satisfied, to administrate software problems/anomalies, to witness critical software tests, and to fulfill other assurance functions as necessary to meet requirements of the subcontract. The Subcontractor shall notify ATK SQA of peer and formal reviews.

3.10.4.1 Software Verification and Validation (V&V)
The Subcontractor shall implement a V&V function on all deliverable software. This function will be responsible for the following software tasks:

a. Stress-testing,
b. End-to-end testing,
c. Testing of fault-protection features,
d. Traceability matrix between requirements and test-cases,
e. Defining/implementing regression testing, following all version changes,
f. Fault tree analysis for safety critical functions, or those functions that control hazard.

The V&V test requirements (conditions, pass/fail criteria) shall be clearly documented, and the as-run results shall be part of the final data package.